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Abstract

This paper presents the rationale and design for a collaborative virtual environment that is being developed to aid shared assessment of urban planning proposals. The research aims to show how a collaborative virtual environment system can be constructed, applied and used in the context of urban planning. A navigable and interactive collaborative virtual environment is being created in which planning information is embedded and analytical tools are provided. Sharing the virtual experience can improve the collaboration among the planning officers, applicant, engineers, developers and the public. These participants can use the system to explore alternative designs independent of time and place. The system will be suitable for discussions during the development plan and development control (decision-making) process. The system aims to improve communication amongst the involved parties and in turn enhance the quality of decisions made by a planning committee. Better informed decisions will increase the confidence that the public has in the urban development process. The research aims to analyse the usability of a collaborative virtual environment system, not only in terms of its visual and communicative impact, but also its impact on the decision-making process.

1. Introduction

Collaborative virtual environments (CVEs) bring virtual reality (VR) to computer supported cooperative work (CSCW). They enable natural forms of communication and interaction in a virtual medium that also allows interactions with 3D representations of the environment being worked on. They are emerging as a new type of tool for supporting cooperative work in the varied fields of design, visualization, simulation, training and education, as well as entertainment [13]. Examples of existing CVEs are DIVE, MASSIVE, dVS, COVEN etc. [3,4,5,8,9,13]. This research focuses on how CVEs can be used to aid urban development planning.

There are two main processes in urban planning: (1) preparation of the development plans and (2) development control. Development plans are policy-based plans that set out the policies to be applied when considering applications for planning permission. Development control is the activity by which permits are issued for urban developments that conform to the development plans and guidelines [2]. Most planning officers in western Europe are employed as development control officers in local councils or as private planning consultants advising and representing clients seeking planning permission [2]. A few planners from different regions are elected as members of the planning committee, which is a part of the local government. The planning committee along with the planning officers are usually the main participants in the urban development control process.

Planning committees evaluate many planning applications every year. These concern new houses, agricultural and commercial developments, additions to buildings, changes to the use of land and buildings, and displays of advertisements, all of which affect the local community and environment. Anyone wanting to carry out significant development must obtain planning permission by putting forward a proposal to the city council. Planning proposals are first analysed by the planning officers who determine the possible impact that the new development may have on its environment. A report is generated detailing this analysis and presented to the planning committee who are finally responsible for granting or rejecting planning permission. These written reports are usually accompanied by illustrations, diagrams or video clips. In the UK, the committee meets every two weeks on average, to approve multiple planning proposals collectively and rapidly. A number of site visits relating to these proposals are also performed. Apart from these site visits the committee mostly has to rely on information submitted by the planning officers before they make a final decision.

Sometimes physical models are built to aid their assessment. But, models are difficult to view from different perspectives, and people usually have to crouch down to view them properly. Moreover, with an isolated model of the new development without its surroundings, it is generally not possible to get a clear idea of its impact on and relationship with the environment. Models are also often scaled differently, which makes it hard to consider their relative effects. Plans drawn by architects can also be difficult to interpret and can be idiosyncratic in their interpretation of a proposal. Similarly photographs or drawings are made from a particular perspective like an aerial or front view, and may not be sufficient to get the whole picture and form the basis for making better decisions.

As urban development management has grown more complex there has been a corresponding increase in the number of commercially available computerised planning tools such as CAD, GIS and VR. These tools are quite suited to facilitating urban planners in their decision-making process. For example, the usefulness of GIS includes: rapid and easy access to large volumes of data; selection of information by area or theme; ability to search for particular features; simulation; modelling and integrating different types of information [15]. Similarly, CAD technology is increasingly used to simulate urban form and to aid the decision-making process. VR technology enables environments to be created and interacted with directly, considerably facilitating the process of visualization and the evaluation of alternative urban planning scenarios impacts in real time. VR technology is supported by web-based online environments, which makes it widely available.

2. Research motivation

Conventional CAD, GIS and other simulation systems lack the capability to support effective communication among the possibly geographically separated parties involved in a decision-making process. Although GIS is a very efficient information visualization tool it does not allow direct interaction or dynamic modification of the underlying data model. CAD provides another way to construct and visualize spatial data, but does not offer explicit planning analysis tools. It follows that the development of a tool, which allows stakeholders in an urban development project to simulate and visualize development control as a part of a shared communicational experience, could prove to be invaluable. An integration of collaboration, visualization, interaction, and simulation techniques supported by a set of guidelines would make the permit process more accessible.

The research was motivated by this lack of an appropriate shared visual representation for urban planners to aid demonstration, collaboration and proper assessment of the urban environment. A CVE system is being developed to evaluate its ability to support urban planning. CVE technology can provide insights that would not be offered as readily by other technologies. This environment can enable parties to explore visually the impact of

new developments on its surrounding urban fabric. It can support collaboration between planners, specialists and members of the public involved in the project to make the urban planning process more effective and urban development more sustainable. Using CVEs, the experience of 3D models is no longer constrained to the individual, but becomes a shared experience enabled by the Internet. This collective participation can bring the public and the participants in the process of negotiation closer together. Seamless integration of planning data into the environment can further help planners make better-informed decisions.

The prototype system can assist planners in their development control process by permitting them to interact collectively and independently with the model to examine its conformity to development plans and policy guidelines. For example, in the case of a new shopping complex, vehicle parking and bus lay-by facilities must be provided to ensure that a development works in a functional sense. Similarly the architecture of the building must blend with the surrounding buildings to be visually amenable [17].

Urban management involves several parties who need to interact with each other in the different phases of planning, with any one party generating information that needs to be used by the other parties. It is essential that there is effective communication between the different parties. The system supports communication of knowledge by providing logical and easy to use information storing and retrieving interfaces. This knowledge sharing combined with analysis tools and voice and text communication, will aid and foster constructive discussions. The distributed nature of the system also helps to improve communication between widespread participants. A very common constraint of the current planning process is that although all the planners or committee members may not be able to take part in site visits, they are actively involved in the permit granting process. In the system, such members are enabled to participate more constructively in discussions without the need to rely predominantly on information provided second hand.

In the past few years it has been increasingly popular to involve members of the public who would be affected by the developments and representative organizations in urban development decisions. The requirement for public participation in the UK was embodied in the Town and Country Planning (Scotland) Act in 1972 [17]. Thus, one of the objectives of the system is to increase public participation during all stages of the planning process without increasing the time taken to process applications. The public will be able to see and read about upcoming developments and environmental changes, form their own opinions of their significance and communicate their views in a timely and effective manner.

In addition planning officers can identify problems within the virtual environment (VE) during the decision-making process and solve them prior to granting the planning permission or constructing the facility. The quality of the decision-making process is a direct result of the availability, accessibility and reliability of information, combined with an ability to collaborate and visualize what other parties communicate. Therefore by using the system, the decision-making process in urban planning can be improved, increasing the confidence in these decisions by the applicants and the public.

3. Approach

In this research, the principal innovation is in the application of CVEs to allow visual representation of urban development information and to aid shared assessment of planning proposals by providing embedded analysis tools. A system prototype is under development. Emphasis has been placed on providing a hierarchy of usable visual representations of various kinds of detail and realism and the development of an interface suitable for urban planning professionals.

Information and data from current planning practice are available to use with this system, though additional knowledge elicitation is necessary. Useful information was collected at meetings with planners from the Edinburgh City Council, Edinburgh World

Heritage Trust and Edinburgh College of Art. These meetings took the form of informative presentations followed by question and answer sessions. The knowledge gained has proven useful throughout the research. This information formed the basis from which an initial set of system functionalities was decided upon. This set has been refined during several iterations guided by information collected about systems currently used. Demonstration of the system and feedback from urban planning professionals especially planners from Edinburgh City Council will allow validation of the system and evaluation of the approach's potential extension to other areas.

The research interviews carried out suggest that, once fully developed, the system should provide the following benefits for planners:

- Enable visual impact assessment
- Aid policy compliance checking
- Permit collective exploration of design variations
- Support conferencing in presence of visualization
- Provide illustrations for presentations
- Give the public easy access to current urban development control issues

4. The system

4.1 System operation

Planning officers will be able to use the system to analyse a proposal in the light of its site and their guidelines. The most frequently controlled elements during the development control process are the visual or physical design aspects of the environment such as architectural features, material, colour, height and projections. Non-physical aspects commonly controlled are: sound, and psychological behaviour factors such as privacy, security and convenience [10]. Often planners cooperate closely with experts like an architect to get advice on the aesthetic and functional aspects of the proposal or a traffic engineer for guidance on the design and detail of a road. For example, if a shopkeeper wants to erect a metal grill over windows to protect the property from malicious damage, the architect can ascertain if the grill is likely to be unsightly and detract from the appearance of the streetscape. Similarly, the traffic engineer can suggest if the road facilities are adequate to meet the traffic requirements when a new shopping complex is built. When planning officers require such expert advice, the system will allow them to collaborate with these experts wherever they are situated with minimal requirements for training.

The results of the analysis of a proposal can be illustrated using the system. For major developments at sensitive locations there may be around fifty committee members at a meeting discussing the issue of granting planning permissions. In this situation the system will be usable in the following way: Three or four members can log on to the system at a few workstations while others sit around a discussion table. Contents from any workstation screen can be projected on to a larger screen. Members logged in to the system can constitute a planning officer demonstrating the proposal's analysis, the chairman of the planning committee and one or two other concerned members within the committee. All members can view the information and express their opinions. Alternative design suggestions raised by the attendees can be immediately executed on the system. These changes will be instantly visible to everyone for further assessment.

The members who are logged in can navigate through the VE and view the new development from different perspectives. Important viewpoints can be saved while navigating which allows the user to jump to these locations when necessary. Users can also view the world with effects of fog and light. This is useful to analyse the impact of the proposed development during both day and night conditions. Animation and screen capture are available to produce simulated walk-throughs, presentations and illustrations. Voice

and text messages support natural forms of communication between collaborators, which is an important requirement for planning negotiations.

Development control tasks can be easily performed with the system. Built-in functionality to measure distances can be used to determine dimensions of gap sites or to check if height regulations on buildings are followed. Visibility of any point in space from another point can also be established. This can be valuable when checking if a building obstructs the visibility of important landmarks from the main streets.

Objects can be interactively manipulated to determine possible alternative designs. In a situation where the proposed building might obstruct the visibility of important landmarks, other arrangements, for example by reducing its height or rotating the building by an angle or maybe even moving it to a new position can be considered. Aesthetic elements, such as architectural style or material of a development's facade are issues frequently controlled by the planners. For a new building to blend with its surroundings, it must be similar in character to its neighbouring buildings. In the system, textures can be applied to buildings to determine a visually pleasing facade.

Planners can save changes made to the VE and also important decisions taken during the meeting for future reference. Additional information relating to an object, such as construction details of a building, historical and architectural details about monuments or government buildings, can also be stored with the object. These particulars can help the planners to decide what kind of proposals they can approve adjacent to these buildings and what conditions they must impose on them. These details are available to any user wishing to view the VE. Information on every object and its surrounding objects can help planners to assess the development thoroughly.

The public do not like houses too close to each other because they may cast shadows or impinge privacy. In the UK, there is a requirement of 9 m privacy distance around every house [17]. With the system it is possible to easily show the privacy distance all around the selected house. This will help the planners to decide where new developments should be placed. Day lighting and overshadowing are important issues that are also supported. Planners can provide the position of the sun and the angle of its rays as input and obtain a plane showing sunrays falling on the house. This plane illustrates whether any other house obstructs the sunlight on this house. The same technique is also used in reverse for overshadowing i.e. to determine if this house casts a shadow on any surrounding house.

Another aspect of development control is to identify illegal constructions. Builders sometimes make deviations from plans during construction such as: changing the outline of the building; deviation from the agreed position and orientation etc. [18]. Comparing the completed construction with the model in the system can help to identify these deviations.

Public participation is normally encouraged at every stage of the modern planning process. Applicants for planning permission are usually legally required to notify neighbours of the site to allow them to express their opinion. Neighbours can then consult submitted plans and lodge objections. The system would enable a virtual model of the proposed development to be inspected online from a neighbour's own PC via a broadband connection to the planning department's computing facilities. Objections could be put forward online and stored with the model. In the case of a household being concerned about threats to their privacy from a neighbouring house extension, the householder could inspect the proposal and lodge their objections directly on the system. This would prompt the planning committee to consider alternatives, such as one wall of the extension to be windowless to prevent overlooking [2]. All this can be done with the same tool. This tool could also be used for demonstration purposes at public meetings to inform about proposed changes to a neighbourhood. Provisions are made for the public to access a stored design guide and site brief and also to leave their comments after viewing the proposed changes. Planners can view these comments during their meetings and adopt them as appropriate.

It is essential for the planners to have a clear idea of what the development will look like in reality and what its impact will be on the existing environment. Hence, the committee

often makes several site visits to assess the proposal thoroughly before a decision is made to either grant or refuse development permission. A realistic representation of the site within the system can reduce the need or frequency for such site visits especially when the committee has to address a number of widespread proposals within a short time. In other words the system offers virtual site visits to planners.

Once the committee members make a decision the matter is settled. In the UK, if a proposal is rejected an applicant has the right to appeal to the central government or they can amend the design and resubmit it. The system should reduce appeals and resubmissions by allowing the applicant along with their advisers to collaborate with the committee members, planning officers and specialists to get it right earlier on. Participants can log on to the system and take part in the discussions. Modification of the design and negotiation of the proposal can continue until all parties come to an agreement. In this way, the system facilitates communication of ideas and justification of decisions made by a planning committee.

4.2 System architecture

The system under development will actively share information via a client-server architecture (*see* Figure 1). It is an extension of Geometrek's DeepMatrix 1.1, an existing multi-user VE system based on two open technologies Java and VRML [14]. The developed system replaces DeepMatrix's VRML visual interface with a Java3D interface. Java3D was chosen instead of VRML because it supports highly interactive VEs that require changes based on complex user interaction. Although this can also be done with VRML and JavaScript, a Java3D application can provide a simpler and more elegant solution with the logic and visual interface implemented within the same technology. Java3D also provides better programming control than VRML. Loaders are also available for VRML and some other popular file formats to import models into a running Java3D program. The development of a Java3D interface involved a number of changes basically to improve the way in which manual interactions were handled by the system. Capability to dynamically import VRML and CAD objects were incorporated. A library of pre-defined objects (VRML models containing only geometry) to represent common structures found in a cityscape like houses, trees, streetlights, telephone poles, traffic lights, phone booths and trashcans has already been developed using VRCreator (a free VRML 2.0 authoring tool from Platinum Technology Inc.).

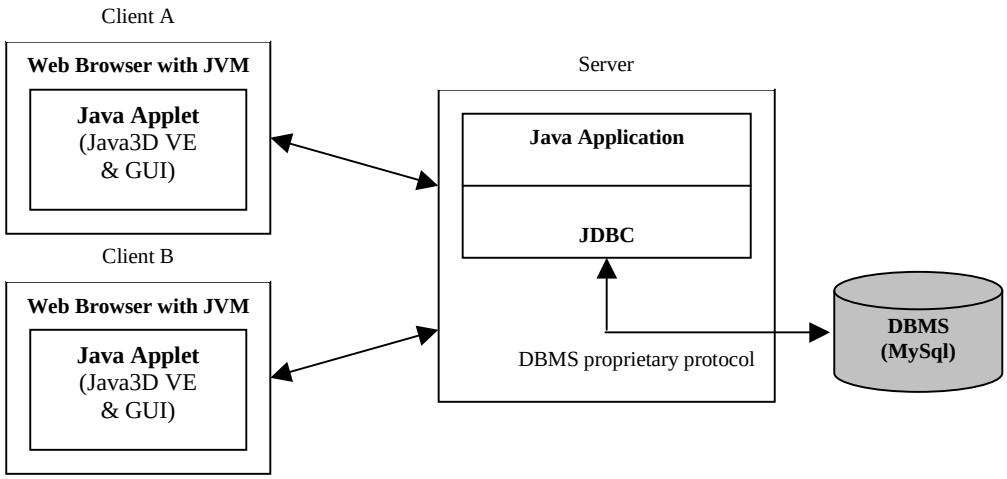

Figure 1: Architecture of the system

The system's client is a Java applet running in a Web Browser. The server program is a Java application that will use Java DataBase Connectivity (JDBC) technology to access a MySql database. The original system's communication service between the client and server had to be extended to support a larger range of messages. A backend database was provided to support persistence of data and to store application domain data against objects. As cross-platform technologies, Java and the Java3D API allow this CVE system to run under many types of operating system. Java and MySql are both open source technologies, which makes it easy to customize them should the need arise. Constant improvements and updates, as well as support from a wide user community are available. Portable, platform independent, object-oriented and open technologies encourage wide potential use of the system.

4.3 User interface & analysis tools

The DeepMatrix 1.1 client provides a very simple user-interface with only a chat panel below the scene displayed by a VRML plug-in, supporting text communication with other clients (*see* Figure 2). The new system's user interface supports visualization and interaction. A Java3D scene loaded with pre-defined VRML objects forms the visualization part of the user interface representing planning information as a VE. Below this is a set of panels supporting various planning tasks. The panels serve both as a means of initiating tasks and providing feedback to the user. After initiating a task, the user can interact with the scene using the mouse or keyboard. Any modifications done to the scene by one user are visible concurrently to all other users. Interaction techniques help the planners not only to view proposed changes from all aspects but also to identify objects or groups of objects in the VE and manipulate them. Besides visual communication, the system also supports voice and textual communication between the participants.

Figure 2: The user interface (Inset: DeepMatrix 1.1 interface)

As shown in figure 2, there are 7 tabs (navigate, object, chat, log, guide/brief, problem/decision, help) that bring up respective panels supporting different functionalities. The panel shown is the object manipulation panel. One part of this panel helps the user to perform common manipulations such as scaling, changing colour, setting transparency, applying texture, making cross sections, displaying privacy area around buildings, showing day light impact and shadows. Another part deals with grouping of objects. Other panels

also group similar tasks together in this way to increase learnability and predictability of the system. Popup menus are a popular context dependent mechanism used to provide access to tasks related to selected elements. Here it is used to provide information and tasks related to the selected objects.

The system supports six different types of users: Planner, Architect, Engineer, Constructor, Applicant and the Public. Each type of user is associated with a set of functionalities appropriate to their role. The planner has access to all functionalities provided by the system whereas the public can only view the VE and express their opinions by writing comments but they cannot manipulate objects. Actions that are unavailable to a particular user are always greyed out. Avatars are used to represent users in order to improve the feeling of presence within the world. There are six different avatar models corresponding to the six types of users. In addition each user is marked with the login name displayed over the avatar's head. The type of user is displayed at the bottom right status area of every panel. The avatar visible in figure 2 is another member within the environment. Likewise, every member logged in to the system will be visible to other members in the world through their avatar.

5. Discussion

In this paper a prototype CVE system for the computer support of collaborative urban planning has been presented. The combination of a collaborative visualization system and an easy to use interaction interface makes the system useful for contemporary urban and environmental planners. The system may bring about positive changes to the current process of urban planning. Because it is a web-enabled technology, it will facilitate the globalisation of urban planning services and will encourage foreign proposals. Having the virtual world available at all times means that planners will require to perform fewer site visits and the decision-making process will allow more iterations in less time because issues can be dealt with more easily. Much of the information necessary for planning is also integrated into the same system. This gives all participants the same information basis for conversation, which should result in a fairer discussion. The use of this tool anticipates an altered planning process in which planning applicants submit proposals and a computer model of the affected buildings with added changes. These models get added to the planning database of the town and become part of the official model if they are accepted. Brief online meetings can be arranged to solve specific issues with only the necessary participants. This could prove more constructive and time-efficient than having meetings at set intervals to resolve all outstanding issues. The system can be used for a number of commercial and householder planning applications concerning new houses, street lights, commercial redevelopment, additions to existing buildings, refurbishment of old buildings, displays of advertisements and similar cases that affect the local community.

The system offers improved communication and accessibility to planning information and hence can increase public participation. The planning process would become more impartial and transparent and there would be less political manoeuvring involved. This will lead to an improvement in the quality of decisions taken which in turn will increase the confidence that people have in these decisions. The above advantages are some of the more important ones identified for planners working with the system. There are other benefits: better visual impact assessment; time saving; more realistic experience of space; providing a fertile context for ideas and thoughts that stimulate collaboration. Though the system supports collaboration, there are pitfalls to be avoided in this area. It is difficult to coordinate and establish a consensus between participants. Trust may not be well established between collaborators especially when they have never met or worked together before. Controlling who can use what resources and when, and protecting data integrity and confidentiality becomes necessary. Effort, education, tolerance and patience are

required to overcome the problems often occurring when people with different backgrounds come together to accomplish a common goal.

The initial cost of creating the virtual model of the existing areas can be expensive but this is only a one-time cost. It is envisaged that once the initial model is created, updating of the model and production of alternative desired views can be done relatively quickly and interactively. If the format of the models is incompatible with the system extra effort has to be put in to convert the data to a suitable format. The technology dependence of such an approach can also create risks. The high cost of the hardware and software involved may also result in slow adoption of this technology. In a few years technology evolution and competition from rival systems could render a collection of virtual models obsolete. Even though the system has high usability, the approach can be time consuming, as participants will need to be trained to use the system. A high bandwidth requirement for fast communication between participants can also cause problems for developing countries where good network facilities are not yet available. Sometimes loss of messages and latency can lead to discrepancies in a shared environment. The probable risks of this approach must be considered in the light of its benefits to make the good use of available technology to improve the urban development process.

To envision the utility of this system, consider a scenario where a US firm is interested in constructing a branch office in Edinburgh, UK. The firm submits their proposal to the Edinburgh City Council along with a VR model of the proposed building developed by their architects. The planning officers can insert this model into their model of Edinburgh City at the proposed site. Analysis of the site and the proposal's impact on its surrounding can be determined. At this point planners can also invite public participation. For example the public can raise their opinion in case the new building is blocking their sunlight. The planning officers can consider these responses as appropriate. This analysis can then be presented to the planning committee for making final decisions. They can collaborate and obtain advice from other technical members like the city architects or engineers to make their decisions. Both voice and textual communication methods can be used for discussions. After careful assessment, if the plan is found to be unacceptable by the committee, they can interact with the VE and determine alternative solutions. The decisions can be discussed and illustrated within the CVE to the applicants situated at their head office in the US. If these changes are not acceptable to the applicant they can communicate with the committee along with their architects, suggesting alternatives more suitable to their needs. In this way different parties can collaborate with each other within the VE until a unanimous and appropriate final decision can be made.

6. Conclusions

The paper briefly describes the challenges faced by urban planners and others engaged in urban development. The research aims to improve the effectiveness of the decision-making process in this field. Reviews of the literature about urban planning and current supporting tools have concluded that there was a need for a system that would support collaborative work on a virtual model that would combine interactive planning tools with direct access to all necessary information [1,6,11,12,15]. After a survey of CVEs and multi-user technologies, an experimental approach to develop such a system as a CVE was found to be most suitable. The basis of the approach is to build on an already existing DeepMatrix multi-user system and provide all the necessary functionality to support the specified benefits of the proposed system.

The results of this project will directly benefit urban planners in their effort to promote a sustainable, functional and pleasant environment. Moreover the system will improve communication of planning information and collaboration between parties involved in a planning project during development plan-making and particularly during the development control decision-making stages of urban planning.

The system facilitates and improves the planning process in the following ways:

- The system can allow planners to share information, to connect, and to communicate as a global community. From these connections they can derive better solutions to global and local environmental challenges. All participants can have uniform access to all necessary information required to make important decisions.
- The system can provide improved communication capabilities compared to traditional methods. Communication is an essential requirement for urban planning.
- The system can increase public participation for environmental assessment. The public can understand new developments and environmental changes by having easier access to information such as guides, briefs and decisions relating to the proposals and so form their own opinions on its significance. Feedback from the public can influence the final outcome of proposals.

This system is envisioned as a "decision" tool that supports the process of decision-making in urban development management. The interface had been designed to be easy to use, intuitive and efficient. The system can be a model for other kinds of interactive decision-making tools.

References

[1] K. Addae-Dapaah, "Utilisation of Urban Residential Land**:** A Case Study of Singapore", Elsevier Science Ltd., 1999, Vol.16, No.2, pp.93-101.

[2] Allmendinger, P., A. Prior, and J. Raemaekers, Introduction to Planning Practice, Wiley, 2000.

[3] S. Benford, J. Bowers, L. Fahlen, J. Mariani, and T. Rodden, "Supporting Co-operative work in Virtual Environments", The Computer Journal, Oxford University Press, 1994, Vol.37, No.8.

[4] W. Broll, E. Meier, and T. Schardt, "The Virtual Round Table- A Collaborative Augmented Multi-User Environment", in Proc. of the ACM Collaborative Virtual Environments (CVE 2000), San Francisco, ACM: New York, 2000, pp.39-46.

[5] C. Carlsson, and O. Hagsand, "DIVE- A Platform for Multi-User Virtual Environments", Computers and Graphics, 1993, Vol.17, No.6, pp.663-669.

[6] V. Coors, U. Jasnoch, and V. Jung, "Using the Virtual Table as an Interaction Platform for Collaborative Urban Planning**",** Virtual Reality & 3D GIS, Computers & Graphics, Elsevier Science Ltd., 1999, Vol.23, pp.487-496.

[7] J.B. Cullingworth, "Aesthetics in US Planning: From Billboards to Design Controls", Town Planning Review, 1991, Vol.62, No.4.

[8] C. Greenhalgh, and S. Benford, "MASSIVE, A Collaborative Virtual Environment for Teleconferencing", ACM Transactions on Computer, Human Interaction (TOCHI), ACM Press, 1995, Vol.2, No.3, pp.239-261.

[9] C. Greenhalgh, and S. Benford, "Boundaries, Awareness and Interaction in Collaborative Virtual Environments", in Proc. of the 6th International Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises, Cambridge, Massachusetts, USA, 1997.

[10] R. Habe, "Public Design Control in American Communities**:** Design Guidelines/Design Review", Town Planning Review, 1989, Vol.60, No.2, pp.195-219.

[11] A.C. Hall, "The Use of Computer Visualisation in Planning Control: An Investigation of its Utility in Selected Examples", Town Planning Review, 1993, Vol.64 No.2, pp.193-211.

[12] B. Huang, and H. Lin, "GeoVR**:** A Web-Based Tool for Virtual Reality Presentation from 2D GIS Data", Computers & Geosciences, Elsevier Science Ltd., 1999, Vol.25, pp.1167-1175.

[13] V. Normand, and J. Tromp, "Collaborative Virtual Environments: The COVEN Project", in Proc. Of the Framework for Immersive Virtual Environments Conference, FIVE'96, Pisa, 1996.

[14] G. Reitmayr, S. Carroll, A. Reitemeyer, and M.G. Wagner, "DeepMatrix – An Open Technology Based Virtual Environment System", The Visual Computer Journal, 1999, Vol.15, pp.395-412.

[15] P. Selman, D. Davidson, A. Watson, and S. Winterbottom, "GIS in Rural Environmental Planning: Visual and Land Use Analysis of Major Development Proposals", Town Planning Review, 1991, Vol.62, No.2, pp.215-223.

[16] S.J. Simoff, and M.L. Maher, "Analysing Participation in Collaborative Design Environments", Design Studies, Elsevier Science Ltd., 2000, Vol.21, pp.119-144.

[17] Thomas, K., Development Control – Principles and Practice, UCL Press, London, 1997.

[18] Z. Zegarac, "Illegal Construction in Belgrade and the Prospects for Urban Development Planning", Elsevier Science Ltd., 1999, Vol.16, No.5, pp.365-370.